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registers zero current (the potentiometer is then said to be balanced). Show that if the balance point is at the midpoint of the wire, then $\mathscr{E}_X = \frac{1}{2}\mathscr{E}_S$. What if the balance point is at three-quarters of the length of the wire?

Ohmmeter

10. An **ohmmeter** consists of a standard source of emf (a battery), connected in series with a standard resistance, and an ammeter. When the terminals of the ohmmeter are connected to an unknown resistor (Figure 29.18), the current registered by the ammeter permits the evaluation of the unknown resistance. Explain.

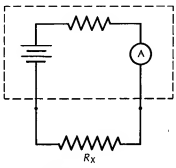

Fig. 29.18

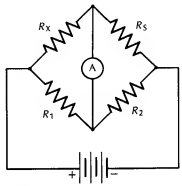

Fig. 29.19

Wheatstone bridge

11. The circuit shown in Figure 29.19 is called a **Wheatstone bridge.** It permits a very precise comparison of an unknown resistance with a known, standard resistance. In Figure 29.19 the unknown resistance is R_X, and the standard resistance is R_S. The resistances R_1 and R_2 are adjustable. In operation, the resistances R_1 and R_2 are adjusted until the ammeter A registers zero current. Show that under these conditions the ratios of the resistances are related as follows: $R_X/R_S = R_1/R_2$.

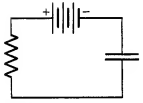

Fig. 29.20

12. At $t = 0$ you connect a battery and a resistor to a capacitor, as shown in Figure 29.20. The capacitor is initially uncharged. Qualitatively, describe the current as a function of time.

13. A homeowner argues that he should not pay his electric bill since he is not keeping any of the electrons that the power company delivers to his home — any electron that enters the wiring of his home sooner or later leaves and returns to the power station. How would you answer?

14. The spiral heating elements commonly used in electric ranges *appear* to be made of metal. Why do they not short circuit when you place an iron pot on them?

15. What are the advantages and what are the disadvantages of high-voltage power lines?

16. In many European countries, electric power is delivered to homes at 220 V, instead of the 110 V customary in the United States. What are the advantages and what are the disadvantages of 220 V?

17. How much does it cost you to operate a 100-watt light bulb for 24 hours? The price of electric energy is 8¢ per kilowatt-hour.

PROBLEMS

Section 29.1

1. The smallest batteries weigh 0.05 ounces and store an electric energy of about 5×10^{-6} kW · h. The largest batteries (used aboard submarines) weigh